Poisson Flow Generative Models

Year: 2022 | Citations: 106 | Authors: Yilun Xu, Ziming Liu, M. Tegmark, T. Jaakkola

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Abstract

We propose a new"Poisson flow"generative model (PFGM) that maps a uniform distribution on a high-dimensional hemisphere into any data distribution. We interpret the data points as electrical charges on the $z=0$ hyperplane in a space augmented with an additional dimension z, generating a high-dimensional electric field (the gradient of the solution to Poisson equation). We prove that if these charges flow upward along electric field lines, their initial distribution in the $z=0$ plane transforms into a distribution on the hemisphere of radius r that becomes uniform in the $r \to\infty$ limit. To learn the bijective transformation, we estimate the normalized field in the augmented space. For sampling, we devise a backward ODE that is anchored by the physically meaningful additional dimension: the samples hit the unaugmented data manifold when the z reaches zero. Experimentally, PFGM achieves current state-of-the-art performance among the normalizing flow models on CIFAR-10, with an Inception score of 9.68 and a FID score of 2.35. It also performs on par with the state-of-the-art SDE approaches while offering $10\times $ to $20 \times$ acceleration on image generation tasks. Additionally, PFGM appears more tolerant of estimation errors on a weaker network architecture and robust to the step size in the Euler method. The code is available at https://github.com/Newbeeer/poisson_flow .